System impedances for power cable Umbilicals

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The demand for electric power in the oil and gas sector is increasing as processing systems are moved subsea. These systems are supplied by high voltage cables concealed in a special designed umbilical together with hydraulics lines, service lines, injection systems, fibre optics, communication cables and low voltage supply cables for instrumentation and control. Typical loads are variable speed drives operating at frequencies varying from 50 to 200 Hz. As the umbilicals are exposed to large mechanical static and dynamic forces during installation and operation, proper armouring (steel reinforcements, carbon fibre etc.) is required.

For designing the electrical system, the characteristic electrical properties of all elements at relevant frequencies are required. For the power circuits, the phase impedances (positive, negative and zero sequence) of each power circuits are needed to calculate impedance asymmetry related to motor acceptance levels, grounding currents, corrosion issues and leakage currents. For the remaining components, induced currents and voltages are of importance. Some of the fundamental values may be found in datasheets, but these are often IEC-specifications. The accuracy of these values is therefore questionable.

Experiences from project work show that the required values may be calculated accurately using electromagnetic 2D numerical software if correct input values are used and the influence of armouring (especially steel) and internal twisting are included properly. 3D models may incorporate twisting, but several simplifications are often implemented as these models tend to be large and complex. Measurements are therefore needed to acquire accurate data for calibration of the utilized model.

A proprietary measurement method and plan providing all relevant electrical data and properties have been developed. This includes measurements of per phase impedances and induced voltages and currents for relevant grounding conditions. An important issue is how the parameters depend on different operation conditions (applied voltage, current and frequency), grounding, temperature and twisting conditions.